DEVICE AND METHOD OF CONTROLLING A DRIVE UNIT

Background Information

The present invention relates to a device and a method of
controlling a drive unit, in particular an internal combustion
5   engine in a vehicle.

German Patent Application 42 31 449 A1 describes a device for
controlling the drive power of an engine having at least two
control units, a first control unit being connected to a first
10   group of measuring devices and a second control unit being
connected to a second group of measuring devices of the same
measuring element. There are special advantages of an engine
which has two independent cylinder blocks and is controlled by
two control units or controllers. Due to the fact that
15   multiple control units are connected to only one measuring
element for detection of the performance quantity, a high
availability and operating reliability are guaranteed. The
system presented here having two control units has an
asymmetrical functionality and program code and originally has
20   a main computer, which is heavily utilized, and an emergency
computer, which is only lightly utilized. Individual functions
of the main computer are shifted to the emergency computer to
optimize computation time and memory.

25   Instead of two controllers, German Patent Application
    35 39 407 A1 describes a computer system having two processors
for regulating characteristic quantities of an internal
combustion engine. The two processors share the computer load
in normal operation, each of the two processors being able to
30   maintain emergency operation as an emergency computer in the

event of malfunction. Thus, only the functions needed in
emergency operation are implemented on both processors.
However, in emergency operation these functions have a reduced
extent of performance and function in comparison with normal

5   operation. Due to this increased redundancy and division of
work in normal computer operation, which is possible as part
of the emergency function, reliability and operating speed may
be increased.

10   Due to the asymmetrical division of functions of each
controller or processor, the respective functionality must be
defined, implemented, documented, tested, and maintained
separately. Likewise, both controllers or computers must be
equipped in the development stage with expensive measuring

15   means and/or emulation means. Due to the asymmetrical
definition of the functionality and therefore the asymmetrical
definition of the systems, additional errors may occur due to
a mix-up during assembly of the components, for example. At
the same time, a further development of or change in

20   functionality in the existing system requires that both
controllers or computers and their respective functionalities
be taken into account, which consequently is very complicated,
time consuming and cost intensive.

25   This results in the object of implementing an engine control
system having a very high functionality which is optimized
with respect to the related art.

       This is achieved through the characterizing features of the
30   independent claims.

       Advantages of the Invention

       A control system of a drive unit, in particular of an internal
35   combustion engine having a control unit where the control unit
contains at least two computers, is described. The
functionality of the control unit or controller, too complex

for one computer, is divided among at least two computers in one controller. The program memories of the two computers or computing units contain the same program code, so that both computers have an identical possible functionality. Thus the

5   individual functionalities are advantageously selectable to be less complex than the required overall functionality, so that the complex overall functionality is nevertheless obtained via all computers or processors. In use, largely the same program code is run through, although there may be individual parts

10   that are present in both memories or computers but are processed asymmetrically, i.e., only in or from one memory.

The functions may advantageously be divided among more than two computers, or additional computers may be present in the

15   overall system, although they execute a different program code, i.e., they have a different functionality. The computers may then be appropriately accommodated in different controllers.

20   The two computers having identical possible functionalities may appropriately exchange information, e.g., over a serial or parallel bus system such as a CAN bus or other serial interfaces or a DPRAM. It is also advantageous that the functionality need only be defined, implemented, documented,

25   tested and maintained once due to the symmetrical division of function and the identical functionalities, but it may be used for both computers or computer units.

In manufacturing the controller, e.g., in prototype building

30   or in production, the program memory which contains the program code and thus the functionality is advantageously assembled twice in the controller, so there is no possibility of mix-ups.

35   In the development and application phase, one may appropriately concentrate on one of the symmetrical sides. It is sufficient to equip one side with expensive measuring means

or emulation devices. Due to the symmetrical division of functions and the symmetrical functionality on both computers, a modular design of the controller and the controller program is possible. This makes further developments through changes

5   in existing functions and/or introduction of new functions much easier and faster in comparison with an asymmetrical structure because there are no interface problems or timing problems between the functions distributed among the computers. This results in lower development costs and shorter

10   development times.

The main point is thus the symmetry and functionality of the computer system and the use of program memories having a completely identical program code for the at least two

15   computers or computing units in the controller.

Additional advantageous embodiments are characterized in the description and claims.

20   Drawing

The present invention is explained in greater detail below on the basis of the embodiments illustrated in the drawing. Figure 1 shows a block diagram of a control unit having two

25   computing elements or computers which control at least one performance quantity in the vehicle, preferably the performance of a drive unit, in particular of an internal combustion engine.

30   Figure 2 illustrates functional relationships between the two computers in the controller and their environment.

Figure 3 shows the concrete embodiment in functional relationships based on lambda regulation for calculation of

35   injection in the internal combustion engine.

Description of the Exemplary Embodiments

Figure 1 shows an electronic controller 100, which includes at
least two computers 101 and 102, an input module 103, an
5   output module 104 and a bus system 105. Other components
and/or modules may optionally be connected to bus system 105
as indicated by element 106. These additional optional
elements include, for example, additional memory elements
and/or an additional bus input/output interface, e.g., for
10   diagnosis or for connection of controller 100 to other
controllers. Input module 103 may be combined with output
module 104 as well as the input/output module. Computer 101
contains, among other things, a processor 109 and a program
memory 107 assigned to this processor 109. The program code
15   filed in program memory 107 corresponds to the possible
functionality with regard to the control or regulation of at
least one performance quantity such as that which is
processable by processor 109. It is advantageous for the
reasons given above if first computer 101 and second computer
20   102 have a completely identical design, likewise with a
processor 110 and a program memory 108 allocated to them.
However, different computers may optionally also be used as
long as the possible functionality of both computing units is
identical. Input module 103 receives signals which represent
25   measured performance quantities of the drive unit, the drive
train and/or the vehicle or from which such performance
quantities may be derived. In particular, these are
performance quantities which may be analyzed to control an
internal combustion engine. These signals are picked up by
30   measuring devices 111 through 113, in particular sensors, and
are sent to input module 103 via input lines 114 through 116.

Furthermore, signals which actuate control elements or
actuators for setting at least one performance quantity of the
35   drive unit, in particular the internal combustion engine of
the vehicle, are also output via output module 104. The
corresponding signals for controlling actuators 117 through

119 are delivered via output lines 120 through 122. Depending on the input signals, performance quantities and/or internal quantities derived from them, computers 101 and 102 form values for the controlled variables which are to be output and

5   which set the control elements in the sense of a predetermined control or regulatory strategy as part of the programs implemented therein. Controller 100 is preferably a control unit for controlling a drive unit, in particular of an internal combustion engine, of a vehicle, so the position of

10   an operating element that may be operated by the driver is detected and analyzed in a known way and a setpoint value for a torque of the drive unit is determined. A setpoint value for the torque is then determined by taking into account setpoint values of other control systems received over input module

15   103, e.g., a traction control, a transmission control, etc., as well as setpoint values formed internally (limits, etc.). Then in a preferred embodiment of an internal combustion engine control system, this is converted to a setpoint value for setting the throttle valve, which is set as part of a

20   position control loop. Furthermore, depending on the design of the internal combustion engine, additional performance-determining functions are provided, e.g., a control for a turbo charger of an exhaust gas recycling system, an idling speed regulation, etc.

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In addition, with internal combustion engines having direct gasoline injection, not only the air setting but also the determination of the fuel mass to be injected, the determination of an air/fuel ratio to be set, the preselection

30   of the injection course (pre-injection, post-injection), the control of a charge movement valve, etc., have a crucial effect on performance, so that, in addition to the programs described there, a plurality of other programs are to be provided which have an influence on the performance of the

35   internal combustion engine and thus on the safety of the vehicle.

This plurality of programs is filed or may be installed in the form of a program code in respective program memories 107 and 108 of the computer. The functionalities of a controller represented by the programs or program code in the program

5   memory as described here are generally very complex. Therefore, these complex functionalities of the controller should be divided symmetrically between at least two computers in such a controller. The computers may exchange information, e.g., over a communication system, in particular a bus system

10   such as a CAN bus or another serial or parallel interface or a memory element, in particular a DPRAM. Program memories 107 and 108 of two computers 101 and 102 contain the same program code. In addition, the identical program code is also executed to a great extent, but there may be individual parts which,

15   for some reason, are processed asymmetrically. For example, the required programs or sections to be processed asymmetrically may then be activated or deactivated via hardware lines and signals transmitted on them. For the sake of simplicity of the diagram, these line connections are

20   represented by communication system 105 and/or are integrated into it.

The procedure described above is illustrated in Figure 2 with regard to a division of functions F1 through F4 as an example.

25   The controller is again labeled as 100, and the two computers are labeled as 101 and 102. An internal combustion engine having the respective actuators and sensors is labeled as 200. This specific example shows an internal combustion engine having 12 cylinders divided into two cylinder blocks of six

30   cylinders each. The 12 cylinders are shown only as an example, and it is equally possible for a different number of cylinders to be provided in respective cylinder blocks 200a and 200b, each having the respective sensors and other actuators. Thus, in a 12-cylinder engine, for example, six cylinders are

35   operated by each computer with regard to ignition and injection in a gasoline engine. The functionality is distributed symmetrically among the two computers.

Functionality F1 controls one cylinder block with the respective sensors and actuators of the internal combustion engine. Sensor quantities such as the air/fuel ratio, the camshaft or crankshaft position, knocking information, air

5   mass, etc. from internal combustion engine 200 are sent to computers 101 and 102, in particular their functionality F1 (205, 206). Actuating signals (204, 207) from functionality F1 reach the internal combustion engine or its actuators. Oriented connections 204 through 207 represent the

10   functionality of the transmission per se.

There is also the possibility of utilizing circuit parts or sensors via both processors. For example, the sensor, e.g., a hot film air mass flow sensor and an input circuit, e.g., a

15   low-pass filter, may be present only once for cost reasons, but the sensor signal, e.g., an A/D-converted air flow, is available to the functionalities in both computers.

Likewise, a controller, e.g., a secondary air pump having the

20   corresponding output stage in the controller may be operated by only one computer, whereas the respective engine function, e.g., the secondary air control including diagnosis, runs symmetrically in both computers and also supplies quantities for other engine functions.

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In addition, actuators such as secondary air valve for a first cylinder block may be operated by the computer for the other cylinder block, namely the second, although the respective engine function is running in the computer for the first

30   cylinder block.

Another possibility is for the program code for operation of the actuator, e.g., for regulating the position of the throttle valve, to run symmetrically in both computers, in

35   which case, however, the output stage and the actuator are operated on one cylinder block, but on the other cylinder block the signal from the computer is not used for control

purposes.

Due to the embodiments described above as well as the
following description of the tank system, it is obvious that
5   despite the identity of the functionalities and the program
code, certain asymmetries are possible.

Additional peripherals such as a tank system 201 are
controlled and monitored by another functionality F2. This
10   functionality F2 is likewise contained symmetrically in both
computers 101 and 102. However, it is processed only
asymmetrically by computer 101, for example. Therefore, this
functionality F2 is activated or deactivated by signals of
separate hardware lines or by unambiguous signals or data over
15   the communication system. Thus, if there is only one tank in
the vehicle, diagnosis of the tank is performed in only one
computer. Although corresponding functionality F2 is present
on both computers in the program memory, it is activated on
only one side. The communication relationship between
20   functionality F2 in computer 101 and tank system 201 is
represented by connections 202 and 203.

In addition, functionalities F3 and F4 may also be provided
for other peripheral elements, so that, on one hand, sensor
25   elements 209 and 210 may be input and processed via
communication link 213 and 214 (F3). On the other hand,
control elements, actuators 208 and 211 may also be operated
via communication links 212 and 215 by functionalities F4.
Likewise, quantities to or from other control systems such as
30   a traction control, a transmission control, etc. may be
relayed via oriented connections 212 through 215. If sensor
element 209 and control element 208 are elements of the same
control loop, functionalities F3 and F4 may also be considered
together as functionality F34.

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Figure 3 shows a very special embodiment of a 12-cylinder
engine having a concrete functionality. Thus, this 12-cylinder

engine has four parallel exhaust gas lines, for example,
having four regulating probes 310 through 313, combined as
lambda probes 300. Thus a quadro lambda regulation would have
to be provided in the engine control unit, but because of its

5   high complexity this entails not only increased costs but also
risks with regard to malfunctions, in particular security
risks. Due to the symmetrical division of functions between
two computers, there is only one stereo-lambda regulation in
each computer 101 or 102 in controller 100, i.e., the

10   functionality is far less complex. The signals supplied by
probes 310 through 313 go via interfaces 314 through 317 for
hardware processing. This signal processing takes place
through elements 308 and 309 for computer 101 and through
elements 306 and 307 for computer 102. Probe signals US1 and

15   US2 are thus sent to computer 102, and probe signals US3 and
US4 are sent to computer 101.

Thus only two probe signals are analyzed in each computer, and
the lambda regulation factors act, as explained later, only on

20   six injectors via the injection calculation. Then, as stated
previously, the same-stereo lambda regulation is performed in
block 304a and 304b. To do so, processed probe signals US1 and
US2 enter the regulation as probe signals USX and USY.
Likewise, processed probe signals US3 and US4 in block 304b

25   also enter as USX and USY into the same stereo-lambda
regulation. Regulating factors FRX and FRY that are obtained
from the stereo-lambda regulation are relayed to downstream
blocks 305a and 305b for computer 102 and computer 101,
respectively.

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Based on regulation factors FRX and FRY, the same injection
calculation is then performed in blocks 305a and 305b for six
injectors in this embodiment. The resulting output quantity
groups 318 and 319 are then relayed to output stage blocks 320

35   and 321.

On the basis of the same program code or the identical

functionalities, the function blocks are also identical. Likewise, input quantities, output quantities and state variables of computers 101 and 102 have identical designations. Output quantities 318 and 319 are equally

5   designated as ti1 through ti6, although they have physically different meanings. Thus, ti1 is used once for controlling injector 1, EV1, and once for controlling injector 7, EV7. However, this has no relevance for the function or functionality or the program code. Injectors 301 are then

10   controlled via interface 302 or 303 from output stage blocks 320 and 321.

The symmetrical distribution of functions discussed above is illustrated in Figures 1, 2 and 3, although parts may be

15   processed asymmetrically. Nevertheless, the functionality and the program code are identical for both computers and are run through in both computers independently of one another. There is no redundancy and there are no emergency operating properties in sensors, output stages or functionality. Such a

20   redundancy would have to be generated additionally, independently of the concept according to the present invention.